(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 December 2001 (13.12.2001)

PCT

(10) International Publication Number
WO 01/93903 A1

(51) International Patent Classification[7]: A61K 39/02, 39/12, 39/39, 39/00, A61P 37/00

(21) International Application Number: PCT/EP01/06437

(22) International Filing Date: 7 June 2001 (07.06.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
A 1000/2000 8 June 2000 (08.06.2000) AT

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

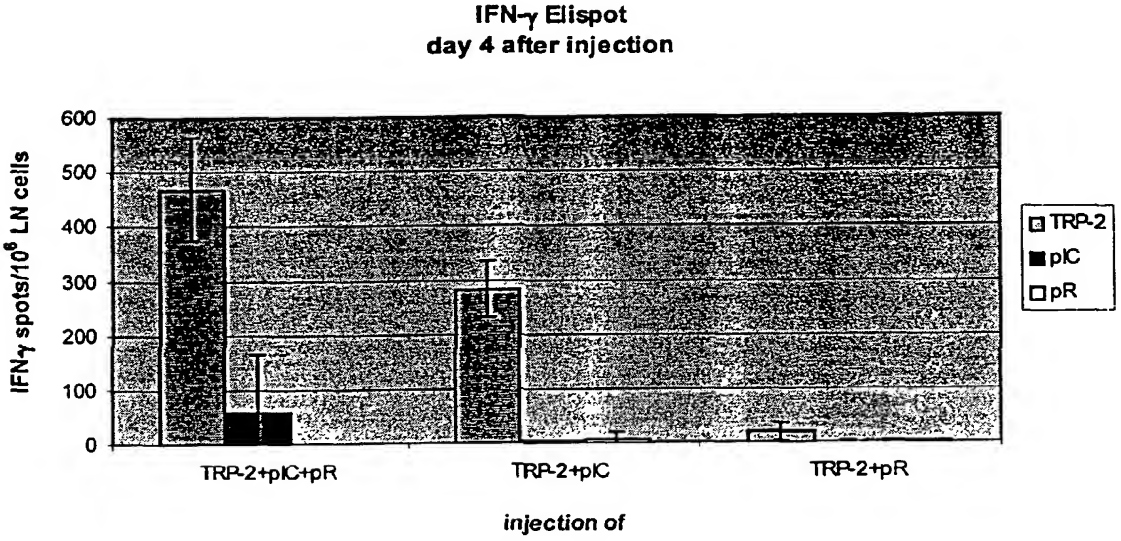
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** ANTIGENIC COMPOSITION COMPRISING A POLYCATIONIC PEPTIDE AND INOSINE AND CYTOSINE



(57) **Abstract:** The invention relates to a composition comprising: a T cell epitope or a mixture of T cell epitopes, a polycationic peptide and a nucleic acid based on inosin and cytosin and its use as a vaccine.

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ANTIGENIC COMPOSITION COMPRISING A POLYCATIONIC PEPTIDE AND INOSINE AND CYTOSINE

A vaccine can contain a whole variety of different antigens. Examples of antigens are whole-killed organisms such as inactivated viruses or bacteria, fungi, protozoa or even cancer cells. Antigens may also consist of subfractions of these organisms/tissues, of proteins, or, in their most simple form, of peptides. Antigens can also be recognized by the immune system in form of glycosylated proteins or peptides and may also be or contain polysaccharides or lipids. Short peptides can be used since for example cytotoxic T cells (CTL) recognize antigens in form of short usually 8-11 amino acids long peptides in conjunction with major histocompatibility complex (MHC) (Rammensee et al., 1995).

In order to obtain sustained, antigen-specific immune responses, adjuvants need to trigger immune cascades that involve all cells of the immune system necessary. Primarily, adjuvants are acting, but are not restricted in their mode of action, on so-called antigen presenting cells (APC), of which dendritic cells (DCs) are the most potent. These cells usually first encounter the antigen(s) followed by presentation of processed or unmodified antigen to immune effector cells. Intermediate cell types may also be involved. Only effector cells with the appropriate specificity are activated in a productive immune response. The adjuvants may also locally retain antigens and co-injected other factors. In addition, the adjuvants may act as a chemoattractant for other immune cells or may act locally and/or systemically as a stimulating agent for the immune system.

Cells of the innate immune system recognize patterns expressed on their respective targets. Examples are lipopolysaccharides (LPS) in the case of Gram-negative bacteria, mycobacterial glycolipids, lipoteichoic acids of Gram-positive bacteria, mannans of yeast and double stranded RNAs of viruses (Hoffmann et al., 1999). In addition, they may recognize patterns such as altered glycosylations of proteins on tumor cells.

Polycationic polymers, for example the polycationic amino acid polymers poly-L-arginine and poly-L-lysine, have been shown to allow very efficient charging of APC with antigens in vitro and in vivo (Buschle et al., 1998, Buschle et al., 1997, Schmidt et al., 1997). This is thought to be the key event for triggering immune cascades, eventually leading to the induction of antigen-

specific immune effector cells that are able to destroy or neutralize targets. It has been shown previously that a number of polycationic compounds exert effects on immune cells (Buschle et al., 1998, Buschle et al., 1997).

Co-injection of a mixture of poly-L-arginine or poly-L-lysine together with an appropriate antigen as a vaccine protects animals from tumor growth in several animal models (Buschle et al., 1998, Schmidt et al., 1997). This chemically defined vaccine is able to induce a high number of antigen-specific T cells. In order to induce antigen-specific T cells, peptides need to be taken up by APC. Such peptide-loaded APC will induce an immune cascade, eventually leading to the induction of antigen-specific immune effector cells like T cells.

Polyinosinic-polycytidylic acid (poly I:C) is known as a potent interferon type I inducer (Manetti et al., 1995). Because of its protective effects in a number of animal species against a broad spectrum of both RNA and DNA viruses (e.g., herpes simplex virus, rabies virus, Japanese B encephalitis virus, vaccinia virus, encephalomyocarditis virus), poly I:C is often used in models of viral infections. Changes that occur in response to poly I:C are thought to be representative of changes that occur in response to a variety of different viruses. Poly I:C is known to stimulate macrophages to produce cytokines such as IL-1a and IL-12 (Manetti et al., 1995), it is a potent NK cell stimulator (Cavanaugh et al., 1996) and, in general, this compound is known to promote Th1-specific immune responses. Because of these abilities, poly I:C has been widely applied as an immunomodulator in several clinical trials showing little or no toxicity (Guggenheim et al., 1977, Simnaler et al., 1977). However, there was no patient benefit. It is unclear whether poly I:C on its own has adjuvant activity. Recent findings show that poly I:C also induces stable maturation of in vitro-cultured DCs and that such DCs are potent T cell stimulators in vitro (Cella et al., 1999; Verdijk et al., 1999).

It is an object of the present invention to provide an effective vaccine system to allow an effective delivery of a specific antigen to the immune system of man or animal to achieve an efficient immunization against such an antigen.

This object is solved by a pharmaceutical composition comprising a T cell epitope (i.e. an antigen recognized by T cells)

or mixtures of T cell epitopes, a polycationic peptide and a nucleic acid based on inosine and cytosine.

It has surprisingly turned out that, although polycationic peptides and nucleic acids based on inosine and cytosine have been previously known as being efficient adjuvant substances, the combination of both substances with a T cell epitope shows synergistic effects in immunostimulation which by far exceeds their additive contributions.

Moreover, whereas in previous uses of polycationic peptides and/or nucleic acids based on inosine and cytosine in vaccines only large antigens or whole cell vaccines have been used (where no synergistic effect of the two components may be seen), it could be shown by the present invention that on a T cell level antigens may be provided in a vaccine which gives an efficient T cell response. Immunisation with large antigens or even whole cells, results in the generation of antibodies. According to the present invention, such antibody generation is not an object. Therefore, the compositions according to the present invention preferably contain antigens lacking B-cell epitopes and containing only antigens having one or more specific T cell epitope(s).

Indeed, it could be shown that also weakly immunogenic T cell epitopes which normally give no T cell response ("normally" = either alone, with adjuvants according to the prior art or with only one immunostimulatory substance according to the present invention), may be formulated into very efficient T cell vaccines by combining it with a polycationic polypeptide and a nucleic acid based on inosine or cytosine. Therefore, vaccines according to the present invention may also comprise T cell epitopes which do not result in a sufficient T cell response under "normal" conditions (i.e. in vaccine compositions according to the prior art as defined above). The term "antigen" hereinafter relates to "T cell epitope(s)".

Especially antigens may be successfully used in the present invention, which do not result in a sufficient immune response when applied with alumn, the standard adjuvant (or other prior art adjuvants are disclosed e.g. in Singh et al. (Nat. Biotechnol. 17 (1999), 1075-1081)) or with polycationic polypeptides or nucleic acids based on inosine and cytosine alone. A sufficient immune response may be regarded e.g. resulting in more than 50, preferably more than 200, especially more than 400 IFN-γ spots/10^6

unseparated cells in an Elispot-assay.

Preferably, the nucleic acid based on inosine and cytosine is selected from poly I: poly C, poly IC, poly dC: poly dI and poly dIC. Of course, any other combinations of complementary double-stranded IC sequences are also preferred as well as chemically modified nucleic acids, e.g. thiolated poly IC as described in US 6 008 334; US 3,679,654 and US 3,725,545.

Polycationic peptides to be used in the present invention are e.g. described in the WO97/30721. Preferred polycationic peptides are poly-lysines, poly-arginines and poly-peptides containing more than 50% of basic amino acids, especially arginine or lysine residues, in a range of more than 5, especially more than 8 amino acid residues or mixtures thereof. These polycationic peptides may be produced chemically or recombinantly or may be derived from natural sources. Preferred polycationic peptides derived from natural sources include HIV-rev or HI-tat derived cationic peptides, antennapedia peptides, cationic antimicrobial peptides, defensins, chitosan (or other derivates of chitin) and other peptides derived from these peptides or proteins by a biochemial recombinant production. Preferably, the polycationic peptides contain between 10 and 1000 residues, especially between 50 and 500 residues. Preferably, these peptides contain more than 70%, especially more than 85% basic amino acid residues, such as arginine, lysine, ornithine etc., and also synthetic organic polycations (polypeptide-like substances), like polyethyleneimine, histones, protamine, as disclosed in the WO97/30721. Of course, also mixtures of different polycationic peptides or polypeptides may be used.

The antigens to be used in the present composition are not critical. Preferably, peptides derived from a viral or a bacterial pathogen or from fungi or parasites are used as such antigens (including derivatized antigens or glycosylated or lipidated antigens or polysaccharides or lipids). Preferred (human, animal and plant) pathogens are selected from HIV, HBV, HCV, Influenza virus, Rotavirus, Staphylococcus aureus, Chlamydia pneumoniae, Mycobacterium tuberculosis, Streptococcus pneumoniae, Bacillus anthracis, Vibrio cholerae, Plasmodium sp. (Pl. falciparum, Pl. vivax, etc.), Aspergillus sp. or Candida albicans. The derivation process may include the purification of a specific protein from the pathogen, the inactivation of the pathogen as well as the

proteolytic or chemical derivatization or stabilization of such a protein. Alternatively, also parts of the pathogen itself may be used as an antigen. In the same way also tumor antigens (cancer vaccines) or autoimmune antigens may be used in the pharmaceutical composition according to the present invention. With such compositions a tumor vaccination or a treatment for autoimmune diseases may be performed.

The antigens are preferably peptide or protein, carbohydrate or lipid antigens or mixtures thereof. Antigens from parasites or plant pathogens are also preferred.

Preferably, the antigen is a peptide consisting of 6 to 20, preferably, 7 to 15, especially 8 to 11, amino acid residues. Antigens of this length have been proven to be especially suitable for T cell activation.

According to another aspect the present invention relates also to the use of a composition according to the present invention for the preparation of a vaccine.

The relative amounts of the ingredients of the present composition are highly dependent on the necessities of the individual composition, e.g. the polycationic peptide to be used. Preferably between 1 µg and 1 g of antigen, polycationic peptide and nucleic acid based on inosin and cytosin are applied. In case of poly-L-arginine and poly-L-lysine, preferred amounts of antigen/polypeptide/nucleic acid based on inosine and cytosine lie in the range of 1-10000 µg antigen per vaccination and 0.1 to 1000 µg polypeptid. The amount of poly IC may preferably range from 1 to 5000 µg/kg body weight (10 µg - 500 mg).

The composition according to the present invention may further contain auxiliary substances, such as buffers, salts, stabilizers, antioxidants, etc., or other effective substances, such as antiinflammatoric or antinociceptive drugs.

The present compositions may be applied to a patient, e.g. a vaccination candidate, in efficient amounts, e.g. by weekly, biweekly or monthly intervals. Patients to be treated with the present composition may also be vaccinated repeatedly or only once. A preferred use of the present invention is the active immunization, especially of humans or animals without protection against the specific antigen.

The route of application for the present composition is not critical, e.g. subcutaneous, intramuscular, intradermal or trans-

dermal injection is suitable as well as oral uptake. It is also possible to apply the present composition separately, e.g. by injecting the nucleic acid based on inosine and cytosine separately from the antigen/polycationic peptide composition. The present invention is therefore also directed to a kit comprising a composition containing the antigen and the polycationic peptide as one component and a composition containing the nucleic acid based on inosine and cytosine as a second component. The components may be applied at the same time or site, however, an application at different sites or at a different time or for a different time period is also possible. It is also possible to vary the systemic or local applications of the composition or the components, respectively.

The present invention further relates to the use of the compositions according to the present application for the preparation of a vaccine inducing a systemic immune response.

Details of the present invention are described by the following examples and the figures, but the invention is of course not limited thereto.

Fig.1 shows the immune response against ovalbumin-derived peptide of a combined injection of polyinosinic-polycytidylic acid (pIC) and poly-L-arginine (pR); Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with Ova-derived peptide, pIC or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are expressed as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.2 shows the immune response against ovalbumin-derived peptide of a combined injection of pIC and pR; Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with Ova-derived peptide, pIC or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.3 shows the induction of ovalbumin-peptide specific T cells after combined injection of pIC and pR; Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node

cells were re-stimulated either with Ova-derived peptide, pIC or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.4 shows the immune response against a TRP-2-derived peptide after combined injection of pIC and pR; Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with TRP-2-derived peptide, pIC or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.5 shows the induction of T cells specific for a P1A (mastocytoma-derived) peptide after combined application of pIC and pR; Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with P1A peptide, pIC or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.6 shows the induction of T cells specific for Ova-derived peptide after combined application of oligo-dIC$_{26}$ and pR; Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with Ova-derived peptide, oligo-dIC$_{26}$ or pR. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates.

Fig.7 shows that the combined injection of OVA-derived peptide with pR and pIC induces systemic antigen-specific T cell response; mice were injected subcutaneously either into hind footpads (A) or into the flank (B) with mixtures as indicated. On day 7 after injection, IFN-γ-ELISPOT was carried out with peripheral blood leucocytes (PBLs), which were re-stimulated with OVA$_{257-264}$ peptide. The number of IFN-γ-producing cells was determined 24 hours later. Results are shown as the number of spots/1x10^6 PBLs ± SD of duplicates.

Fig.8 shows that the combined application of OVA-derived peptide with pIC and various polycationic compounds strongly enhances the induction of peptide-specific T cells. Mice were in-

jected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with the relevant peptide ($OVA_{257-264}$ peptide), irrelevant peptide ($TRP\text{-}2_{181-188}$ peptide), pIC, or the respective polycationic compound. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/$1x10^6$ LN cells ± SD of triplicates.

Fig.9 shows that the combined application of ovalbumin (OVA) with pIC and pR strongly enhances the induction of OVA-specific T cells. Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with MHC class I- and II-restricted OVA-peptides or OVA. The number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. The results are shown as the number of spots/$1x10^6$ LN cells ± SD of triplicates.

Fig.10 shows that Poly-L-arginine (pR) does not affect poly-inosinic-polycytidylic acid (pIC)-induced in vitro maturation of human DCs. To determine phenotypic maturation, either pIC, pR, both pIC and pR or, for control purposes, LPS and medium alone was added to day 6-cultured human DCs. Extensive phenotypic analysis of surface antigens was performed after 48 hours of stimulation.

Fig.11 shows that the combined application of OVA-derived peptide with oligo-$dIC_{26\text{-}mer}$ and pR results in the systemic, antigen-specific T cell response. Mice were injected subcutaneously into the footpad with mixtures as indicated in the Figure legend. At selected time points after injection, spleen cells (SCs) or peripheral blood leukocytes (PBLs) were isolated and re-stimulated with OVA-derived peptide. The number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. The results are shown as the number of spots/$1x10^6$ cells ± SD of duplicates.

Fig.12 shows that the combined application of ovalbumin (OVA) with oligo-$dIC_{26\text{-}mer}$ and pR strongly enhances the induction of OVA-specific T cells. A) Mice were injected subcutaneously into the footpad with mixtures as indicated. Four days later, draining lymph nodes (LN) were taken and lymph node cells were re-stimulated either with MHC class I- and II-restricted OVA-de-

rived epitopes or OVA. The number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. The results are shown as the number of spots/1x10^6 LN cells ± SD of triplicates. B) At selected time points after injection, peripheral blood leukocytes (PBLs) were isolated and re-stimulated with $OVA_{257-264}$-peptide. Number of IFN-γ-producing cells was determined 24 hours later using an ELISPOT assay. Results are shown as the number of spots/1x10^6 PBLs ± SD of duplicates.

Fig.13 shows that the combined application of ovalbumin (OVA) with oligo-dIC_{26-mer} and pR enhances production of OVA-specific IgG antibodies. Mice were injected subcutaneously into the footpad with mixtures as indicated. At day 24 and 115 after injection, sera were collected and screened by ELISA for OVA-specific IgG2a (A) and IgG1 (B) antibodies. The results are shown as the antibody titer.

E X A M P L E S

Example 1

The combined injection of polyinosinic-polycytidylic acid (pIC) and poly-L-arginine (pR) synergistically enhances the immune response against ovalbumin-derived peptide.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-Peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-Arginine (pR)	Poly-L-Arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 125H4024) with the molecular weight between 220,000 to 460,000 Dose: 100 µg/mouse

Experimental groups (4 mice per group)

1. $OVA_{257-264}$-peptide + pIC + pR
2. $OVA_{257-264}$-peptide + pIC
3. $OVA_{257-264}$-peptide + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Single cell suspensions were prepared by mincing lymph nodes through a 70 µm cell strainer. Thereafter, cells were washed twice with DMEM medium

(Life Technologies) containing 5% fetal calf serum (FCS, SIGMA Chemicals). Cells were adjusted to 10^7 cells/ml in DMEM/5%FCS. IFN-γ ELISPOT assays were carried out in triplicates as described (Miyahira et al., 1995). This method is a widely used procedure for the quantification of antigen-specific T cells. Lymph node cells were re-stimulated in vitro either with Ova-peptide, polyinosinic-polycytidylic acid (pIC), poly-L-arginine (pR), Concanavalin A (ConA) or medium alone (background). Each spot represents a single IFN-γ-producing T cell. Spots were counted using a Biosys reader (Biosys, Germany). Number of background spots was subtracted from all samples. The Results are expressed as the number of spots/1x10^6 unseparated cells ± SD of triplicates. After the stimulation with ConA we could detect many spots (data not shown) indicating a good condition of the used lymphocytes. As shown in Figure 1, by injecting Ova-derived peptide with a combination of pIC and pR, we could induce almost 800 peptide-specific T cells among one million lymph node cells. In contrast, injections of peptide with either of the substances alone failed to induce peptide-specific T cells (Figure 1).

Example 2

The combined injection of pIC and pR enhances the immune response against ovalbumin-derived peptide in a concentration (pIC)-dependent manner.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-Peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-Arginine (pR)	Poly-L-Arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 125H4024) with the molecular weight ranging from 220,000 to 460,000 Dose: 100, 50, 25 µg/mouse

Experimental groups (4 mice per group)

1. $OVA_{257-264}$-peptide + pIC 100 µg + pR
2. $OVA_{257-264}$-peptide + pIC 50 µg + pR
3. $OVA_{257-264}$-peptide + pIC 25 µg + pR
4. $OVA_{257-264}$-peptide + pIC 100 µg
5. $OVA_{257-264}$-peptide + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as described in example 1. Results are expressed as the number of spots/$1x10^6$ cells ± SD of triplicates. Even very low dose of pIC (25 µg/mouse) injected in a combination with pR plus peptide leads to the induction of antigen-specific T cells (Figure 2).

Example 3

The combined injection of pIC and pR enhances the induction of ovalbumin-peptide-specific T cells in a peptide concentration-dependent manner.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-Peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analysed by mass spectroscopy for purity. Dose: 300, 100, 50 µg/mouse
Poly-L-Arginine (pR)	Poly-L-Arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 125H4024) with the molecular weight ranging from 220,000 to 460,000 Dose: 100 µg/mouse

Experimental groups (4 mice per group)

1. $OVA_{257-264}$-peptide 300 µg + pIC + pR
2. $OVA_{257-264}$-peptide 100 µg + pIC + pR
3. $OVA_{257-264}$-peptide 50 µg + pIC + pR
4. $OVA_{257-264}$-peptide 300 µg + pIC
5. $OVA_{257-264}$-peptide 300 µg + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as de-

scribed in example 1. Results are expressed as the number of spots/1x10^6 cells ± SD of triplicates. As shown in Figure 3, comparably strong immune response can be induced even when lower peptide dose (100 µg instead of 300 µg/mouse) is used for the vaccination.

Example 4

The combined injection of pIC and pR synergistically enhances the immune response against a TRP-2 (mouse tyrosinase-related protein-2)-derived peptide.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	TRP-2-Peptide (VYDFFVWL), an MHC class I ($H-2K^b$)-restricted epitope of mouse tyrosinase-related protein-2 (Bloom et al., 1997) was synthesized by standard solid phase F-moc synthesis, HPLC purified and analysed by mass spectroscopy for purity. Dose: 100 µg/mouse
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 125H4024) with the molecular weight ranging from 220,000 to 460,000 Dose: 100 µg/mouse

Experimental groups (4 mice per group)

1. TRP-2 + pIC+ pR
2. TRP-2 + pIC
3. TRP-2 + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection

and popliteal lymph nodes were harvested. Preparation of lymph nodes and IFN-γ ELISPOTs were carried out as described in example 1. Results are expressed as the number of spots/1x10^6 cells ± SD of triplicates. Our results show that pIC and pR also synergistically act in inducing TRP-2 peptide-specific T cells (Figure 4).

Example 5

The combined application of pIC and pR strongly enhances the induction of T cells specific for a mastocytoma-derived peptide.

Mice	DBA/2 (Harlan/Olac)
Peptide	Mouse mastocytoma P815-derived peptide P1A (LPYLGWLVF), restricted to MHC class I ($H2-L^d$) (Lethe et al., 1992), synthesized by standard solid phase F-moc synthesis, HPLC purified and analysed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-Arginine (pR)	Poly-L-Arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 125H4024) with the molecular weight ranging from 220,000 to 460,000 Dose: 100 µg/mouse

Experimental groups (4 mice per group)

1. P1A-peptide + pIC + pR
2. P1A-peptide + pIC
3. P1A-peptide + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Preparation of lymph nodes and IFN-γ ELISPOTs were carried out as described in example

1. Results are expressed as the number of spots/1x10^6 cells ± SD of triplicates. As shown in Figure 5, the combined application of pIC and pR induces strong antigen-specific response also in another mouse strain.

Example 6

The combined application of oligo-dIC_{26} and pR synergistically enhances the immune response against ovalbumin-derived peptide.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-Peptide (SIINFEKL), an MHC class I (H-$2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-Arginine (pR)	Poly-L-Arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Oligo-deoxy IC, 26-mer (oligo-dIC_{26})	oligo-dIC was synthesized by standard phosphoamidid chemistry on a 4 µmol scale and purified by HPLC (NAPS Göttingen, Germany) Dose: 5 nmol/mouse

Experimental groups (4 mice per group)

1. $OVA_{257-264}$-peptide + oligo-dIC_{26} + pR
2. $OVA_{257-264}$-peptide + oligo-dIC_{26}
3. $OVA_{257-264}$-peptide + pR

On day 0 mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above mentioned compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Preparation of lymph nodes and IFN-γ ELISPOTs were carried out as described in example 1. Results are expressed as the number of spots/1x10^6 cells ± SD of triplicates. As shown in Figure 6, the combined application of

oligo-dIC_{26} and pR induces strong peptide-specific T cell response.

Example 7

The antigen-specific immune response against ovalbumin-derived peptide induced by combined injection of poly-L-arginine (pR) and polyinosinic-polycytidylic acid (pIC) is systemic.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903; with the average molecular weight (MW) 10,000 Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	polyinosinic-polycytidylic acid (Sigma Chemicals, P-0913, Lot 109H4037) with the molecular weight between 220,000 to 460,000 (average length: 500 bp) Dose: 100µg/mouse

Experimental groups (8 mice per group)

1. $OVA_{257-264}$-peptide + pIC + pR
2. $OVA_{257-264}$-peptide + pIC
3. $OVA_{257-264}$-peptide + pR

On day 0, mice were injected either into hind footpads or into the flank with a total volume of 100 µl (50 µl per each footpad, 100 µl per flank) containing the above listed compounds. Four mice per group were sacrificed 4 days after injection and draining lymph nodes (popliteal and inguinal lymph nodes for footpad

and flank injection, respectively) were harvested. Preparation of lymph nodes and IFN-γ ELISPOTs were carried out as described in example 1.

As already shown in previous examples, by injecting OVA-derived peptide in combination with pIC and pR, strong peptide-specific T cell response could be induced on day 4 in draining lymph nodes. To investigate whether the immune response induced by one single injection of peptide with pIC/pR is systemic, the rest of the animals (four per group) was bled from the tail vein at selected time points after injection, peripheral blood leukocytes (PBLs) were isolated, re-stimulated either with the relevant peptide, pIC, pR, ConA (positive control) or medium alone (background) and the number of IFN-γ-secreting T lymphocytes was determined using an ELISPOT assay. Assays were carried out in duplicates. Each spot represents a single IFN-γ-producing T cell. Spots were counted using a Biosys reader (Biosys, Germany). Number of background spots was subtracted from all samples. Results are expressed as the number of spots/$1x10^6$ cells ± SD of duplicates. After the stimulation of PBLs with ConA, many spots demonstrating a good condition of the used lymphocytes could be detected. These results showed that injection of peptide with pIC/pR indeed results in the systemic response as observed on day 7 in peripheral blood (Figure 7A, B). In contrast, there was almost no or very weak peptide-specific immune response detectable on day 7 when mice were injected with peptide and pR or peptide and pIC. The strong systemic response induced by single injection of peptide with combination of pR/pIC declined rapidly within the next 30 days.

To determine whether any component of the vaccine could have undesired effects for the host, e.g., induce the systemic release of pro-inflammatory cytokines, animals were injected into hind footpads with combinations as mentioned before, sera from mice were collected one hour after injection and were screened for TNF-α and IL-6 by ELISA. Neither TNF-α nor IL-6 could be detected in the serum of any of the mice, whether injected with peptide/pR, peptide/pIC or peptide and the combination of both substances.

These results indicate that the response induced by injection of peptide antigen with a mixture composed of pIC and pR is systemic.

Example 8

The combined injection of polyinosinic-polycytidylic acid (pIC) and various polycationic compounds synergistically enhances the immune response against ovalbumin-derived peptide.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300µg/mouse
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903; with the average molecular weight (MW) 10,000 Dose: 100 µg/mouse
Poly-L-lysine (pL)	Poly-L-lysine, SIGMA Chemicals, P-6516, Lot 78H5910; with the average MW 9,500 Dose: 100 µg/mouse
Poly-L-ornithine (pO)	Poly-L-ornithine, SIGMA Chemicals, P-4538, Lot 57H5515; with the average MW 10,000 Dose: 100 µg/mouse
Diethylaminoethyl-dextran (DEAE-dextran)	DEAE-dextran, chloride form, prepared from dextran of the average molecular weight 500,000; SIGMA Chemicals, D-9885, Lot 39H1323 Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	Polyinosinic-polycytidylic acid (Amersham Pharmacia Biotech, 27-4732, Lot 6034732012) Dose: 50 µg/mouse

Experimental groups (4 mice per group)

1. $OVA_{257-264}$-peptide + pIC + pR
2. $OVA_{257-264}$-peptide + pIC
3. $OVA_{257-264}$-peptide + pR
4. $OVA_{257-264}$-peptide
5. $OVA_{257-264}$-peptide + pIC + pL
6. $VA_{257-264}$-peptide + pL
7. $OVA_{257-264}$-peptide + pIC + pO
8. $OVA_{257-264}$-peptide + pO
9. $OVA_{257-264}$-peptide + pIC + DEAE-dextran
10. $OVA_{257-264}$-peptide + DEAE-dextran

On day 0, mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above listed compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as described in Example 1. Results are expressed as the number of spots/$1x10^6$ cells ± SD of triplicates. As shown in Figure 8, injection of peptide in combination with pIC and any of the above listed poly-cationic compounds (pR, pL, pO, DEAE-dextran) leads to the strong peptide-specific response. In contrast, injection of peptide with either of the substances alone did not induce peptide-specific T cells. Interestingly, a 50-fold higher amount of DEAE-dextran has to be used in combination with pIC to induce the same numbers of peptide-specific IFN-γ-producing T cells as injection of pIC with any of other used polycationic compounds (pR, pL, pO).

Example 9

The combined injection of ovalbumin (OVA) with poly-L-arginine (pR) and polyinosinic-polycytidylic acid (pIC) synergistically enhances the OVA-specific immune response.

Mice	C57Bl/6 (Harlan/Olac)
Ovalbumin (OVA)	Ovalbumin from chicken egg, grade V, SIGMA Chemicals, A-5503, Lot 54H7070 Dose: 50 µg/mouse
Peptides	$OVA_{257-264}$-peptide (SIINFEKL), an MHC class I ($H-2K^b$)-restricted dominant epitope of chicken ovalbumin (Rotzschke et al., 1991), $OVA_{265-280}$-peptide (TEWTSSNVMEERKIKV), an MHC class II ($H-2A^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991) were synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose used for the re-stimulation of lymph node cells: 10 µg/ml.
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903 Dose: 100 µg/mouse
Polyinosinic-polycytidylic acid (pIC)	Polyinosinic-polycytidylic acid (Amersham Pharmacia Biotech, 27-4732, Lot 6034732012) Dose: 50 µg/mouse

<u>Experimental groups</u> (4 mice per group)

1. OVA + pIC + pR
2. OVA + pIC
3. OVA + pR
4. OVA

On day 0, mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above listed

compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as described in Example 1. Results are expressed as the number of spots/$1x10^6$ cells ± SD of triplicates. As shown in Figure 9, injection of ovalbumin (OVA) with either pIC or pR leads to the antigen-specific immune response when compared with injection of OVA alone. However, when OVA is injected with a mixture of pIC and pR, the synergizing effect of both substances can be observed, resulting in enhanced antigen-specific T cell response. Importantly, the IFN-γ production was detected not only upon the re-stimulation with the whole OVA protein but also with both, MHC class I ($OVA_{257-264}$)- and II ($OVA_{265-280}$)-restricted OVA-derived epitopes (Figure 9). These data demonstrate that using the combination of pIC and pR, not only peptides but also whole proteins can be used as an antigen for the vaccine composition.

Example 10

Poly-L-arginine does not affect polyinosinic-polycytidylic acid (pIC)-induced in vitro **maturation of DCs.**

Lipopolysaccharide (LPS)	Lipopolysaccharide from Escherichia coli; serotype 055:B5 (SIGMA Chemicals) Dose: 1 µg/ml
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903 Dose: 10 µg/ml
Polyinosinic-polycytidylic acid (pIC)	Polyinosinic-polycytidylic acid (Amersham Pharmacia Biotech, 27-4732, Lot 6034732012) Dose: 10 µg/ml

Experimental groups

1. medium
2. LPS
3. pR
4. pIC

5. pR+pIC

It has previously been described that pIC, similar to influenza virus infection, triggers maturation of human DCs in vitro (Cella et al, 1999; Verdijk et al., 1999). Human monocyte-derived DCs were used to investigate how poly-L-arginine affects this pIC-induced DC maturation. Human DCs were generated from monocytes. Briefly, peripheral blood leukocytes (PBLs) were isolated from buffy coats of healthy volunteers by Ficoll gradient centrifugation. Monocytes were isolated from PBLs using CD14-coated magnetic beads (Miltenyi Biotec Inc., Germany) applied according to the manufacturer's instructions. Using this method, we obtained >95% $CD14^+$ cells as determined by flow cytometry. These $CD14^+$ monocytes were cultured in RPMI 1640 medium supplemented with 10% FCS (PAA Laboratories, Linz, Austria), non-essential aminoacids, L-glutamin, gentamycin, sodium pyruvate, 100 ng/ml human GM-CSF and 500 U/ml human IL-4 in 6-well tissue plates for 6-7 days. To this end, the cultures contained >80% MHC class $II^+/CD1a^+$ cells (=DCs).

To determine phenotypic maturation, day 6-cultured DCs were stimulated either with pIC, pR or with a combination of both substances for 48 hours and were analyzed for the expression of several surface molecules by flow cytometry. For control purposes, DCs were also stimulated with LPS or were left untreated. As shown in Figure 10, pIC induced an up-regulation of HLA-DR, -DQ and HLA-I molecules, co-stimulatory molecules such as CD40, CD54, CD80, de-novo expression of CD86 and the maturation marker CD83 as well as a down-regulation of CD1a molecules when compared to untreated DCs. The maturation effect of pIC was in all cases comparable to that induced by LPS. In addition, this analysis revealed a slight up-regulation of CD11a, CD11c, CD13, CD25, CD29 and CD50 antigens on DCs upon pIC stimulation. None of the above described phenotypic changes could be observed when DCs were incubated with pR alone. The phenotype of DCs stimulated with a mixture of pIC and pR was similar to that induced by pIC alone (Figure 10).

Therefore, pIC has the capacity to induce maturation of human DCs in vitro, and pR does not affect this pIC-induced differentiation process.

Example 11

The antigen-specific immune response induced by the combined application of antigen with oligo-deoxyIC$_{26\text{-mer}}$ and poly-L-arginine (pR) is systemic.

Mice	C57Bl/6 (Harlan/Olac)
Peptide	$OVA_{257-264}$-peptide (SIINFEKL), an MHC class I ($H\text{-}2K^b$)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991), was synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose: 300 µg/mouse
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals Dose: 100 µg/mouse
Oligo-deoxy IC, 26-mer (oligo-dIC$_{26\text{-mer}}$)	oligo-dIC$_{26\text{-mer}}$ was synthesized by standard phosphoamidid chemistry on a 4µmol scale and purified by HPLC (NAPS Göttingen, Germany) Dose: 5 nmol/mouse

Experimental groups (8 mice per group)

1. $OVA_{257-264}$-peptide + oligo-dIC$_{26\text{-mer}}$ + pR
2. $OVA_{257-264}$-peptide + oligo-dIC$_{26\text{-mer}}$
3. $OVA_{257-264}$-peptide + pR
4. $OVA_{257-264}$-peptide

On day 0, mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above listed compounds. Animals (4 mice/group) were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as described in Example 1.

As already shown previously, the combined application of peptide with oligo-dIC$_{26\text{-mer}}$ and pR induced strong antigen-specific response against OVA-derived peptide on day 4 in draining lymph node cells. To examine whether the immune response induced by one

single injection of peptide with oligo-dIC/pR is systemic, the rest of the mice (4 mice/group) was investigated at selected time points after injection for the presence of peptide-specific IFN-γ-producing T cells in spleen or peripheral blood using an IFN-γ ELISPOT assay. Results are expressed as the number of spots/$1x10^6$ cells ± SD of duplicates. Figure 11 shows that the response induced by the injection of OVA-derived peptide with oligo-dIC/pR is systemic and lasts at least until day 59 after one single injection (the latest time point of investigation). In contrast, the local or systemic response could not be observed when peptide was injected alone, with oligo-$dIC_{26\text{-mer}}$ or pR.

To determine whether any component of the vaccine could have undesired effects for the host, e.g., induce the systemic release of pro-inflammatory cytokines, animals were injected into hind footpads with combinations as mentioned before, sera from mice were collected one hour after injection and were screened for TNF-α and IL-6 by ELISA. Neither TNF-α nor IL-6 could be detected in the serum of any of the mice, whether injected with peptide/pR, peptide/oligo-dIC or peptide and the combination of both substances.

These results indicate that the response induced by injection of peptide antigen with a mixture composed of oligo-dIC and pR is systemic.

Example 12

The combined application of oligo-deoxyIC$_{26\text{-mer}}$ and poly-L-arginine (pR) enhances the ovalbumin (OVA)-specific T cell response.

Mice	C57Bl/6 (Harlan/Olac)
Ovalbumin (OVA)	Ovalbumin from chicken egg, grade V, SIGMA Chemicals, A-5503, Lot 54H7070 Dose: 50 µg/mouse
Peptides	OVA$_{257\text{-}264}$-peptide (SIINFEKL), an MHC class I (H-2K^b)-restricted dominant epitope of chicken ovalbumin (Rotzschke et al., 1991), OVA$_{265\text{-}280}$-peptide (TEWTSSNVMEERKIKV), an MHC class II (H-2A^b)-restricted epitope of chicken ovalbumin (Rotzschke et al., 1991) were synthesized using standard solid phase F-moc synthesis, HPLC purified and analyzed by mass spectroscopy for purity. Dose used for the re-stimulation of cells: 10 µg/ml
Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903 Dose: 100 µg/mouse
Oligo-deoxy IC, 26-mer (oligo-dIC$_{26\text{-mer}}$)	oligo-dIC$_{26\text{-mer}}$ was synthesized by standard phosphoamidide chemistry on a 4 µmol scale and purified by HPLC (NAPS Göttingen, Germany) Dose: 5 nmol/mouse

Experimental groups (8 mice per group)

1. OVA + oligo-dIC$_{26\text{-mer}}$ + pR
2. OVA + oligo-dIC$_{26\text{-mer}}$
3. OVA + pR
4. OVA

On day 0, mice were injected into each hind footpad with a total volume of 100 µl (50 µl per footpad) containing the above

listed compounds. Animals were sacrificed 4 days after injection and popliteal lymph nodes were harvested. Lymph node cell suspensions were prepared and IFN-γ ELISPOTs were performed as described in Example 1. Results are expressed as the number of spots/1x10^6 cells ± SD of triplicates. As shown in Figure 12A, injection of ovalbumin (OVA) with a mixture of oligo-dIC and pR results in enhanced antigen-specific T cell response.

Importantly, the IFN-γ production was detected not only upon the re-stimulation with the whole OVA protein but also with both, MHC class I ($OVA_{257-264}$)- and II ($OVA_{265-280}$)-restricted OVA-derived epitopes (Figure 12A).

To further examine whether the immune response induced by one single injection of OVA protein with oligo-dIC/pR is systemic, the rest of the mice (4 mice/group) was investigated at selected time points after injection for the presence of peptide-specific IFN-γ-producing T cells in peripheral blood using an IFN-γ ELISPOT assay. Results are expressed as the number of spots/1x10^6 cells ± SD of duplicates. Figure 12B shows that the response induced by the injection of OVA with oligo-dIC/pR is systemic and persisting at least until day 97 after injection (the latest time point of investigation). In contrast, the local or systemic response could not be observed when OVA was injected alone, with oligo-dIC_{26-mer} or pR.

These data demonstrate that using the combination of oligo-dIC and pR, not only peptides but also whole proteins can be used as an antigen for the vaccine composition and that the response induced by injection of protein antigen with a mixture composed of oligo-dIC and pR is systemic and longer-lasting.

Example 13

The combined application of oligo-deoxyIC_{26-mer} and poly-L-arginine (pR) enhances the ovalbumin (OVA)-specific humoral response.

Mice	C57Bl/6 (Harlan/Olac)
Ovalbumin (OVA)	Ovalbumin from chicken egg, grade V, SIGMA Chemicals, A-5503, Lot 54H7070 Dose: 50 µg/mouse

Poly-L-arginine (pR)	Poly-L-arginine with an average degree of polymerization of 60 arginine residues; SIGMA Chemicals, P-4663, Lot 68H5903 Dose: 100 µg/mouse
Oligo-deoxy IC, 26-mer (oligo-dIC$_{26\text{-mer}}$)	oligo-dIC$_{26\text{-mer}}$ was synthesized by standard phosphoamidide chemistry on a 4 µmol scale and purified by HPLC (NAPS Göttingen, Germany) Dose: 5 nmol/mouse

Experimental groups (4 mice per group)

1. OVA + oligo-dIC$_{26\text{-mer}}$ + pR
2. OVA + oligo-dIC$_{26\text{-mer}}$
3. OVA + pR
4. OVA

On day 0, mice were injected into each hind footpad with a total volume of 100µl (50µl per footpad) containing the above listed compounds. On day 24 after injection, serum was collected and screened by ELISA for the presence of OVA-specific antibodies. These results show that the injection of OVA in combination with oligo-dIC and pR enhanced the production of OVA-specific IgG antibodies when compared with injection of OVA with each of the substances alone (Figure 13A, B). Interestingly, titers of both IgG2a and IgG1 were increased upon one single injection of OVA with oligo-dIC/pR, implying that both Th1 and Th2 cells were involved. However, after 115 days only the increased IgG2a levels were still detectable in sera of mice injected with OVA and oligo-dIC/pR.

These data demonstrate that the combined injection of OVA with oligo-dIC and pR enhances the OVA-specific humoral response. This response is characterized by the production of both Th1- and Th2-induced antibody isotypes in the early phase, but later, mainly by Th1-induced antibodies.

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C l a i m s:

1. Pharmaceutical composition comprising
- a T cell epitope or a mixture of T cell epitopes
- a polycationic peptide and
- a nucleic acid based on inosine and cytosine.

2. Composition according to claim 1, characterized in that the nucleic acid based on inosin and cytosin is selected from poly I: poly C, poly IC, poly dC: poly dI and poly dIC.

3. Composition according to claim 1 or claim 2, characterized in that the polycationic peptide is selected from polyarginine and polylysine or a polypeptide containing at least 50% basic amino acid residues, especially arginine or lysine residues.

4. Composition according to anyone of claims 1 to 3, characterized in that the polycationic peptide contains more than 5 residues, preferably between 10 and 1000, especially between 50 and 500.

5. Composition according to anyone of claims 1 to 4, characterized in that the T cell epitope is derived from a human, animal or plant pathogen.

6. Composition according to anyone of claims 1 to 4, characterized in that the T cell epitope is derived from a viral or bacterial pathogen.

7. Composition according to anyone of claims 1 to 6, characterized in that the antigen is a protein, carbohydrate or lipid antigen or a mixture thereof.

8. Composition according to anyone of claims 1 to 7, characterized in that the T cell epitope is derived from parasites or plant pathogens.

9. Composition according to anyone of claims 1 to 8, characterized in that the T cell epitope is a peptide consisting of 6 to 20, preferably 7 to 15, especially 8 to 11, amino acid residues.

10. Composition according to anyone of claims 1 to 9, characterized in that it contains

- 1 ng - 1 g, especially 1-10000 µg, T cell epitope (peptide)
- 1 ng - 1 g, especially 0.1-1000 µg, polycationic peptide and
- 1 ng - 1 g, especially 10 µg-300 mg, nucleic acid based on inosine and cytosine.

11. Composition according to anyone of claims 1 to 10, charaterized in that it contains additional substances selected from auxiliary substances and further effective substances.

12. Use of a composition according to anyone of claims 1 to 11 for the preparation of vaccine.

13. Use of a composition according to any one of claims 1 to 11 for the preparation of a vaccine inducing a systemic immune response.

14. Kit for vaccination comprising a component containing a T cell epitope or a mixture of T cell epitopes and a polycationic peptide and a component containing a nucleic acid based on inosine and cytosine.

Figure 1

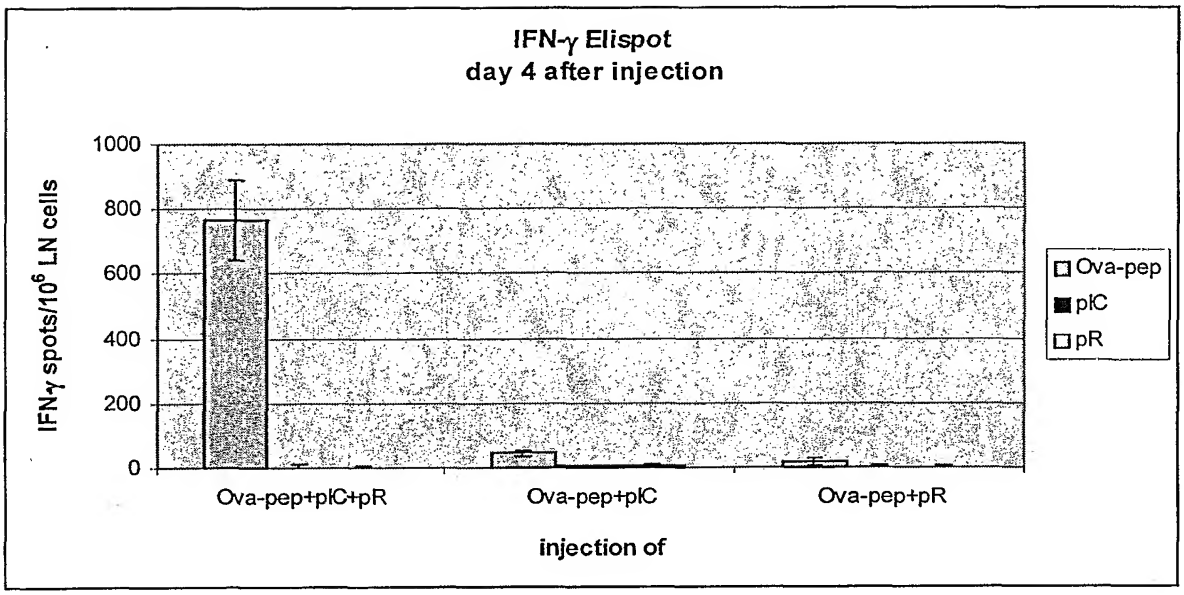


Figure 2

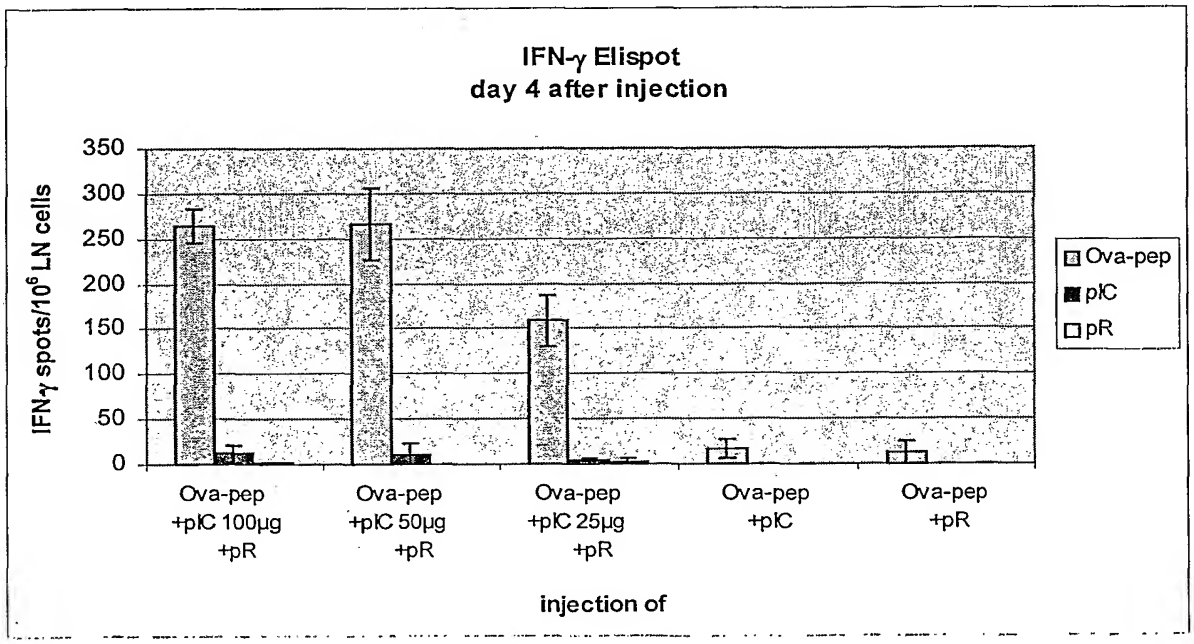


Figure 3

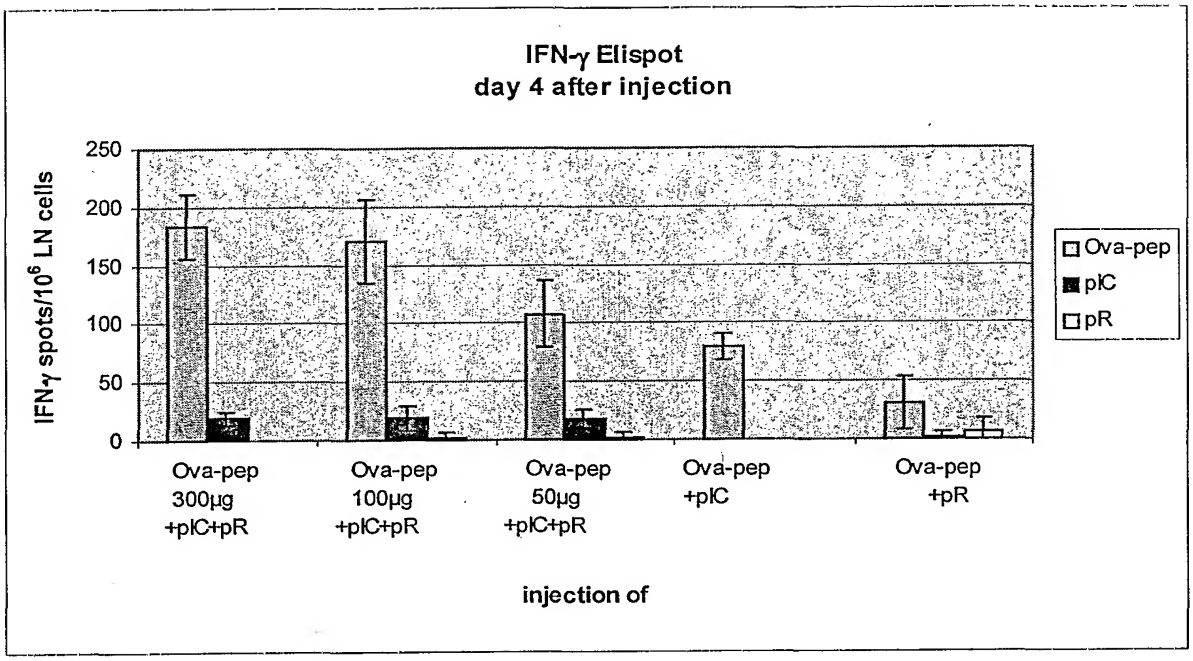


Figure 4

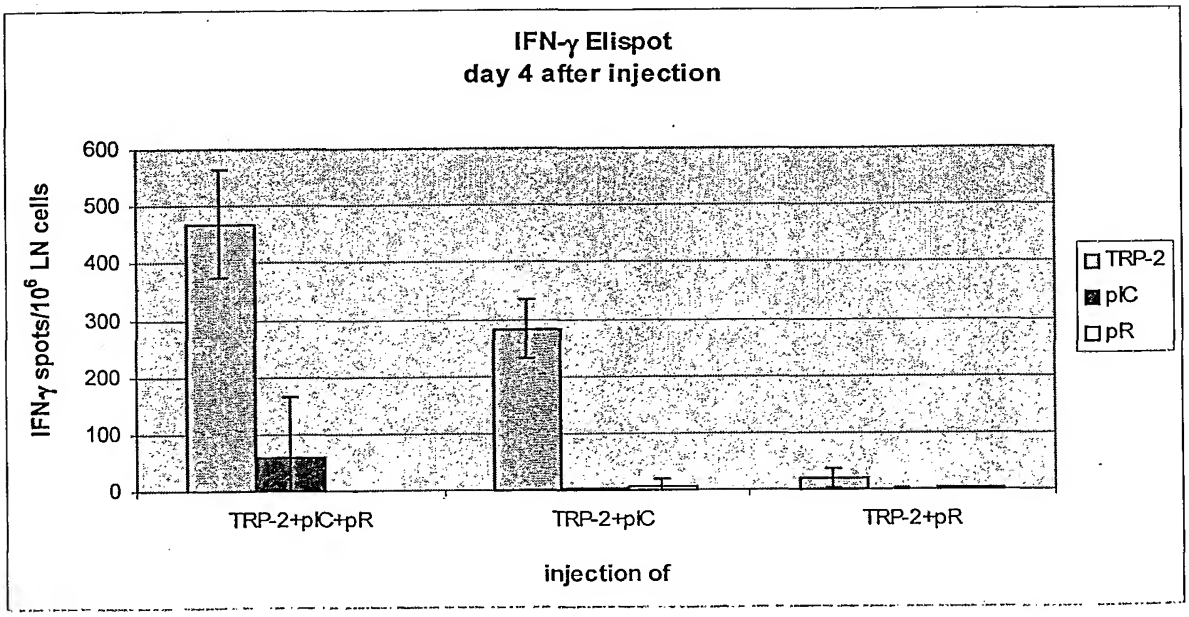


Figure 5

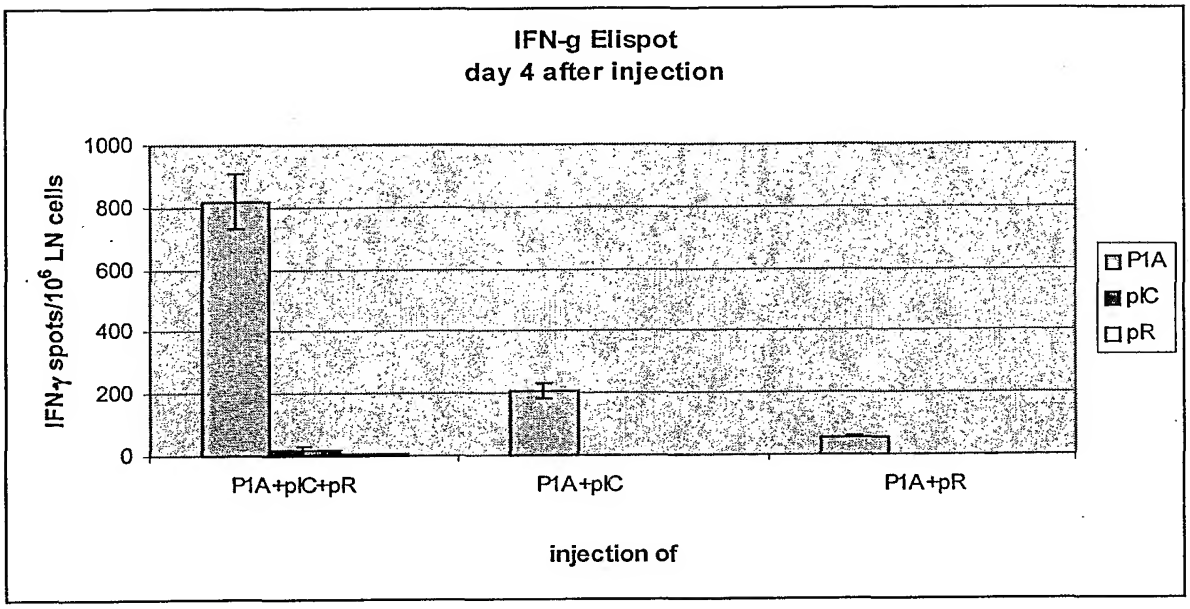


Figure 6

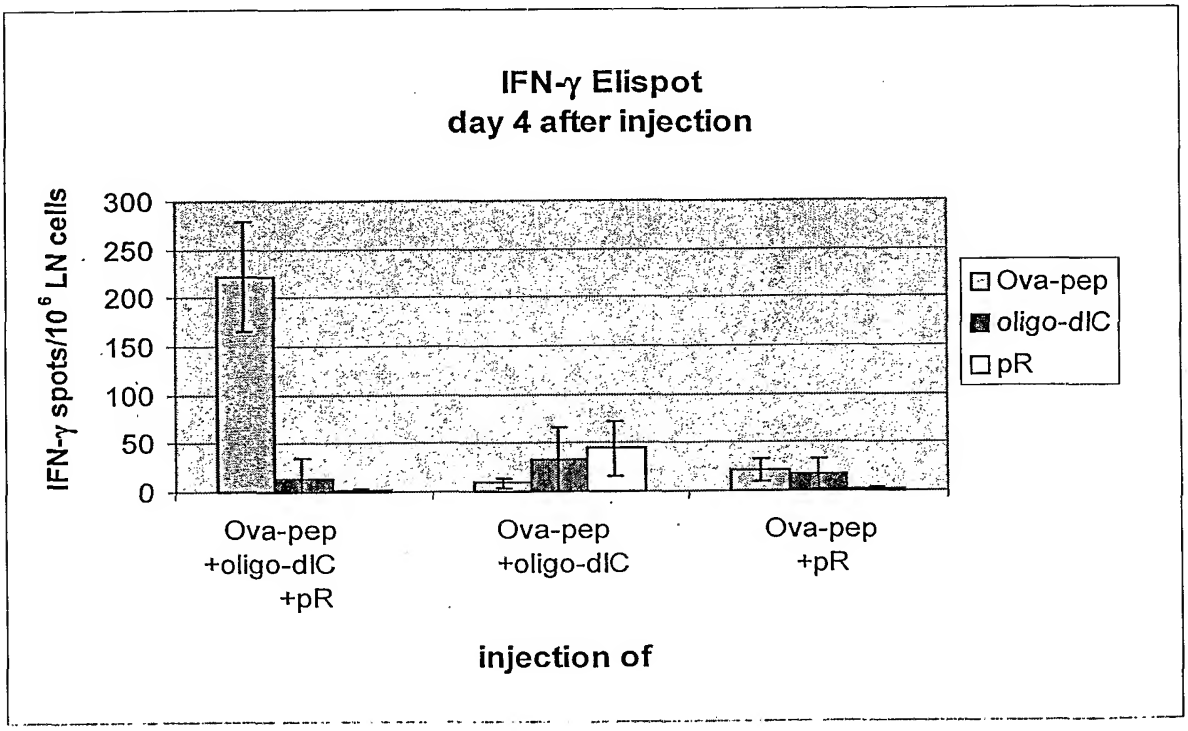
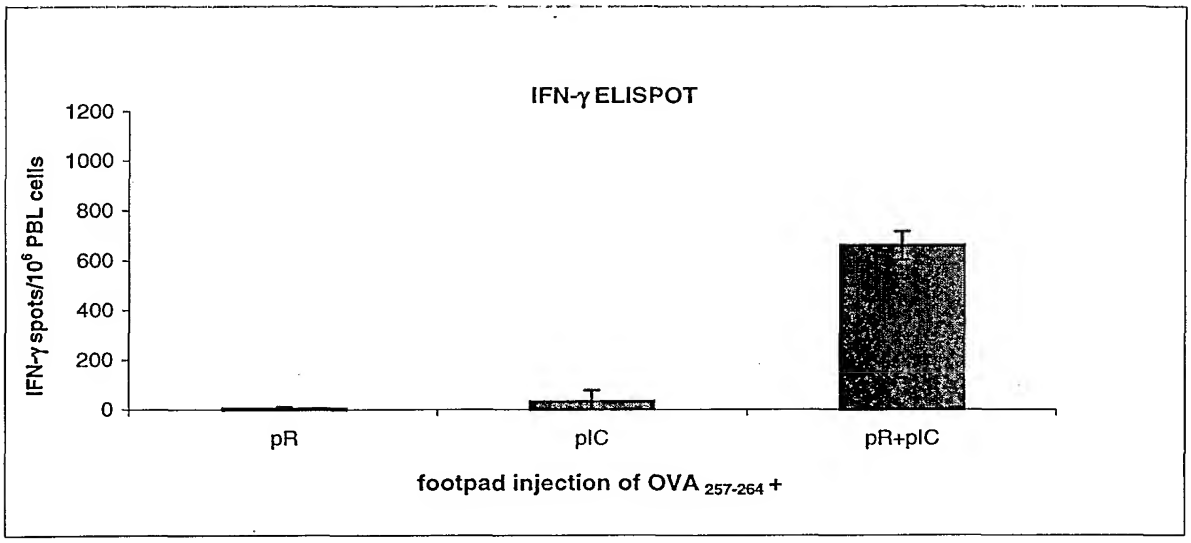


Figure 7

A)


IFN-γ ELISPOT
IFN-γ spots/10^6 PBL cells
1200
1000
800
600
400
200
0
pR
pIC
pR+pIC
footpad injection of OVA 257-264 +

B)

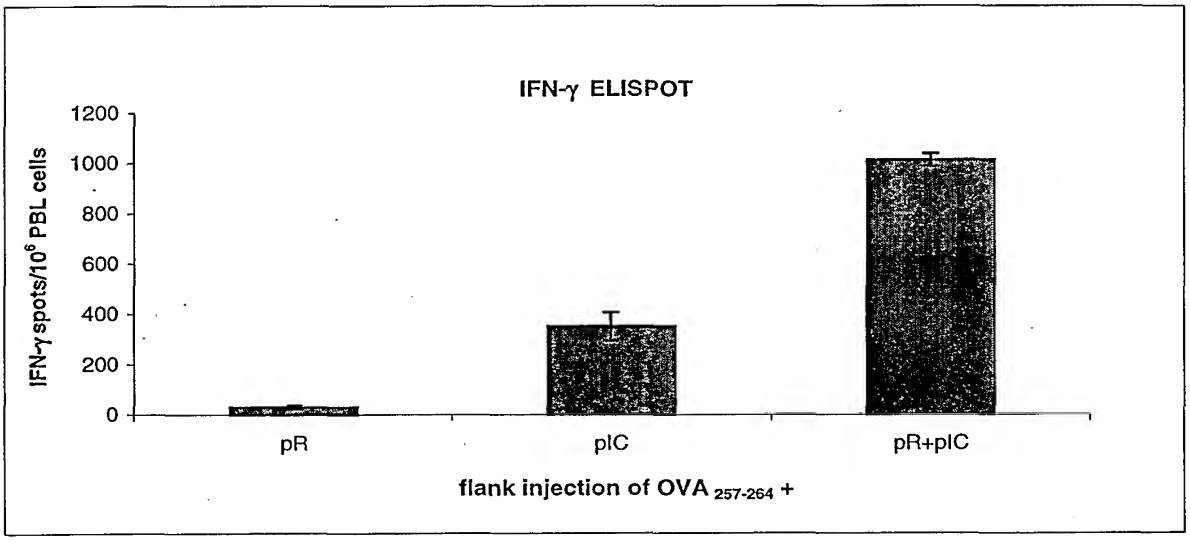

IFN-γ ELISPOT
IFN-γ spots/10^6 PBL cells
1200
1000
800
600
400
200
0
pR
pIC
pR+pIC
flank injection of OVA 257-264 +

Figure 8

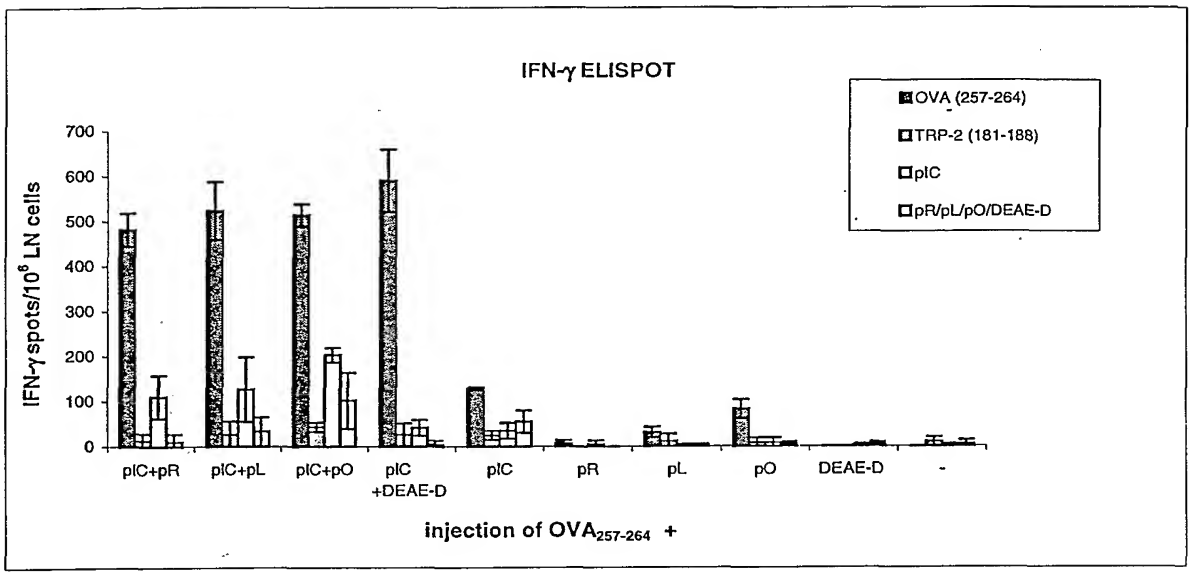


Figure 9

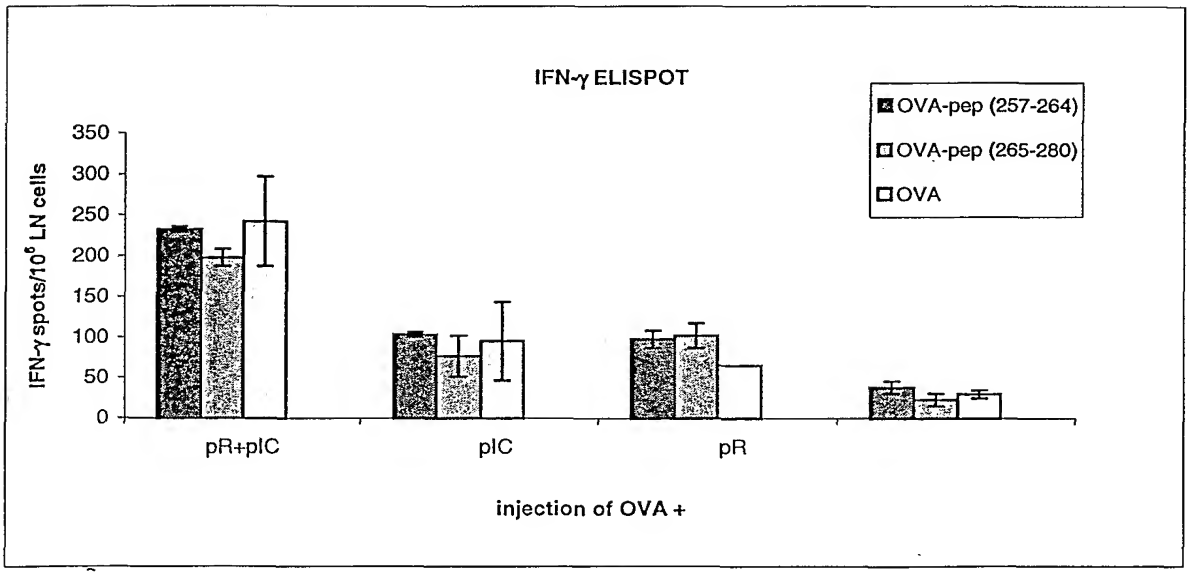


Figure 10

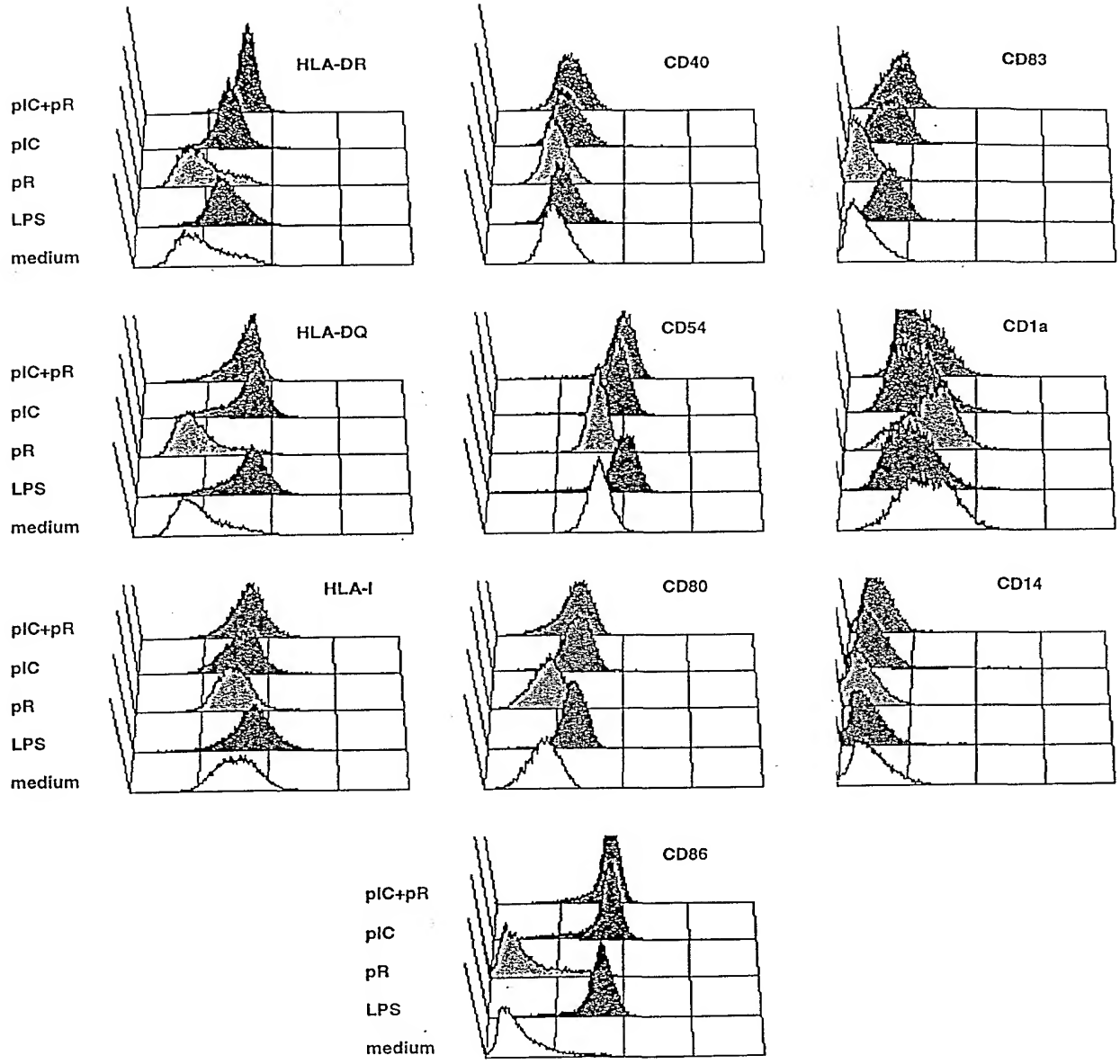

HLA-DR
CD40
CD83
HLA-DQ
CD54
CD1a
HLA-I
CD80
CD14
CD86
pIC+pR
pIC
pR
LPS
medium

Figure 11

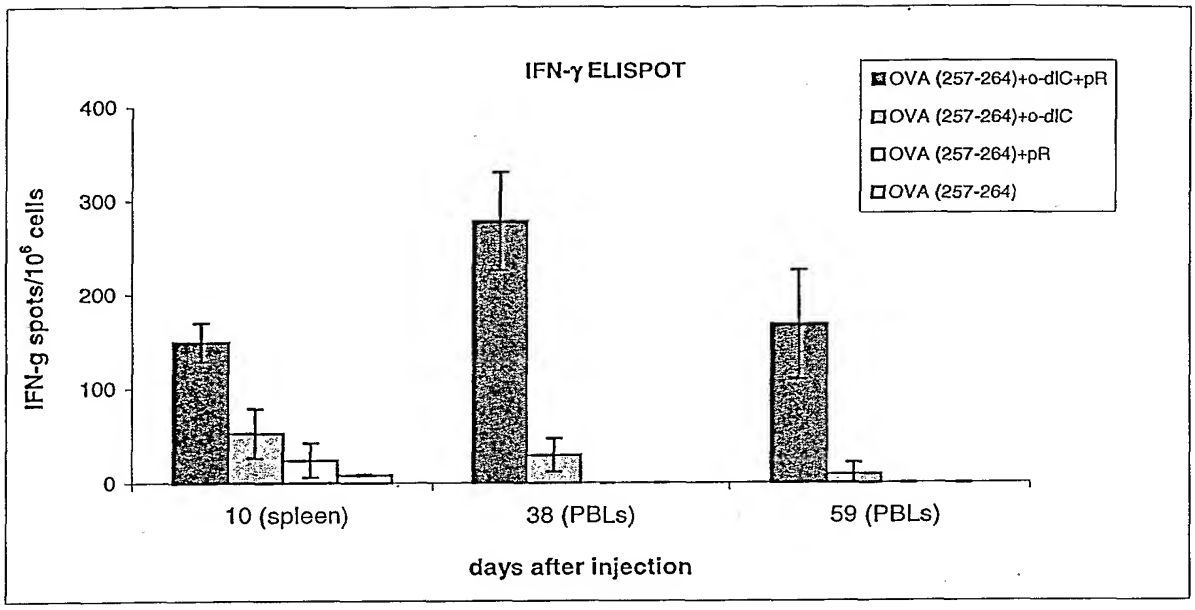
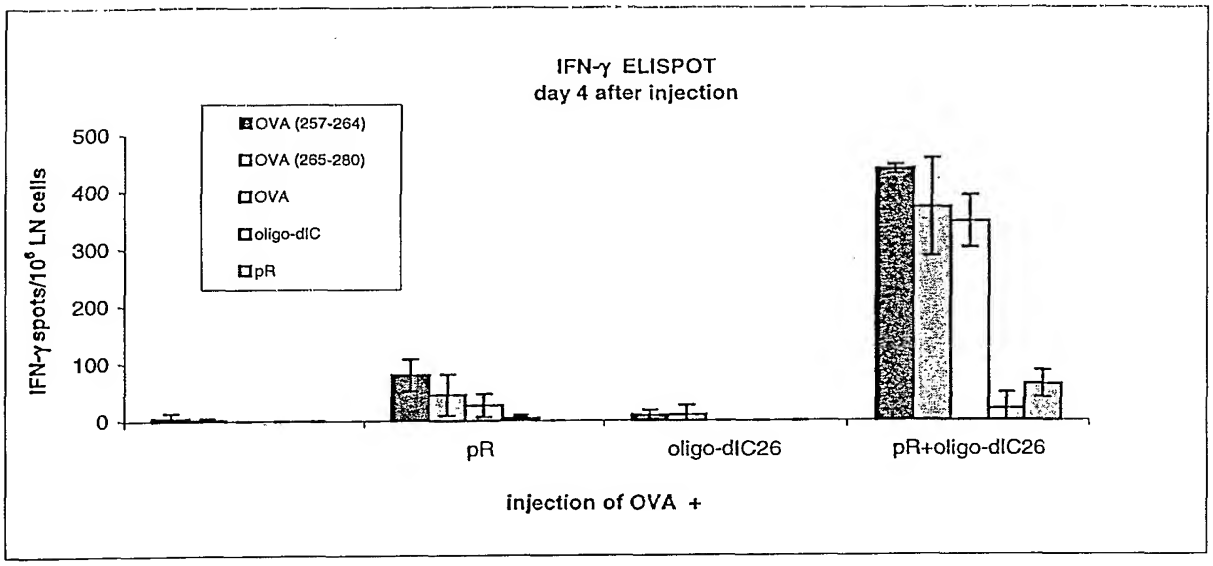

IFN-γ ELISPOT
OVA (257-264)+o-dIC+pR
OVA (257-264)+o-dIC
OVA (257-264)+pR
OVA (257-264)
IFN-g spots/10^6 cells
400
300
200
100
0
10 (spleen)
38 (PBLs)
59 (PBLs)
days after injection

Figure 12

A)


IFN-γ ELISPOT
day 4 after injection
OVA (257-264)
OVA (265-280)
OVA
oligo-dIC
pR
IFN-γ spots/10⁶ LN cells
500
400
300
200
100
0
pR
oligo-dIC26
pR+oligo-dIC26
injection of OVA +

B)

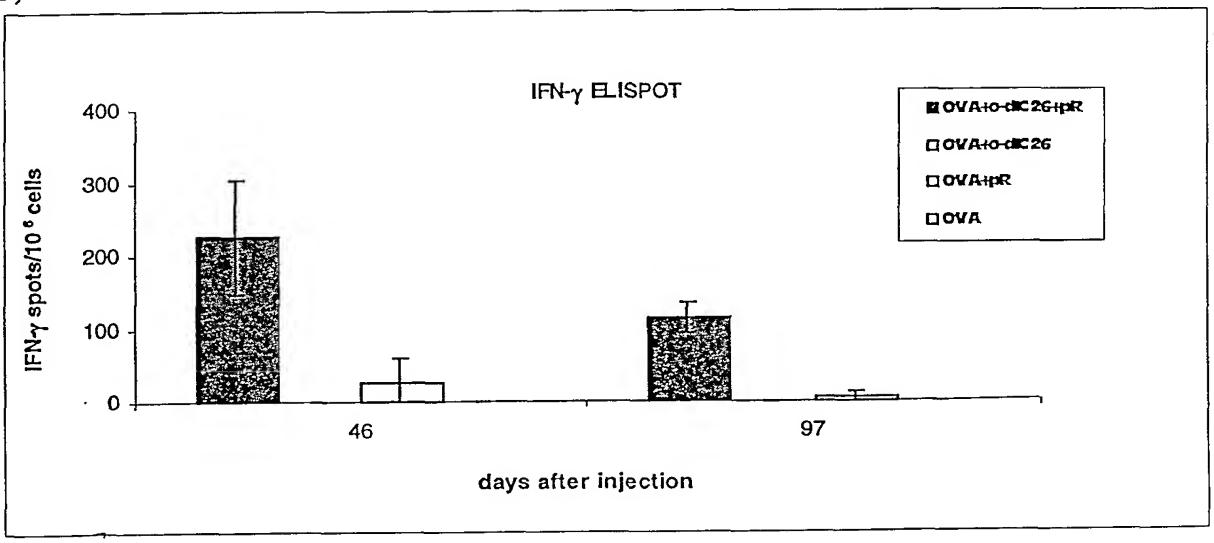
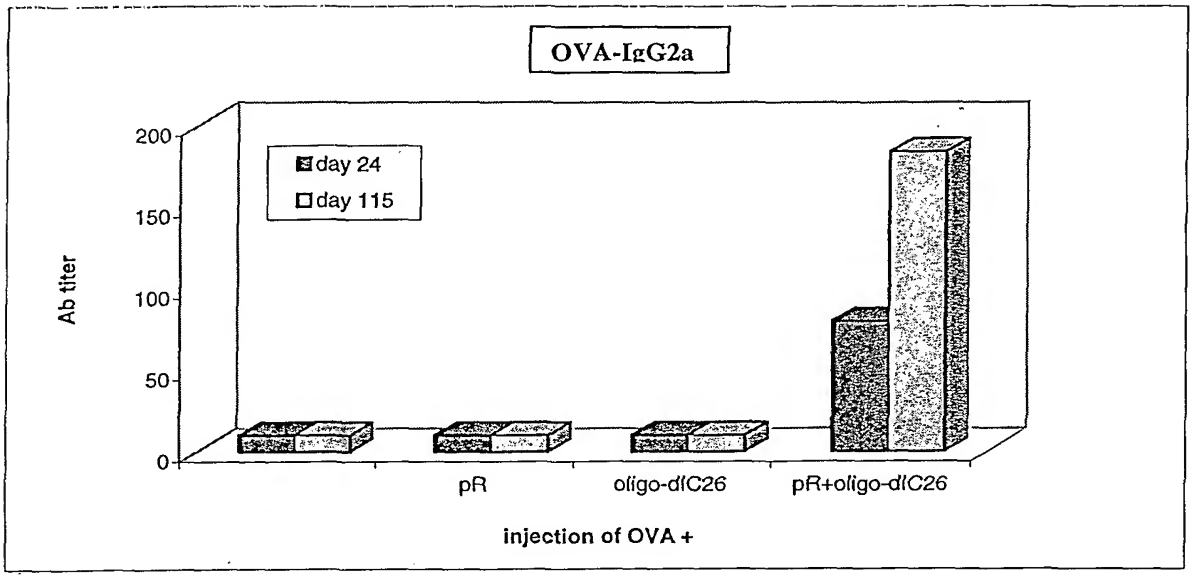
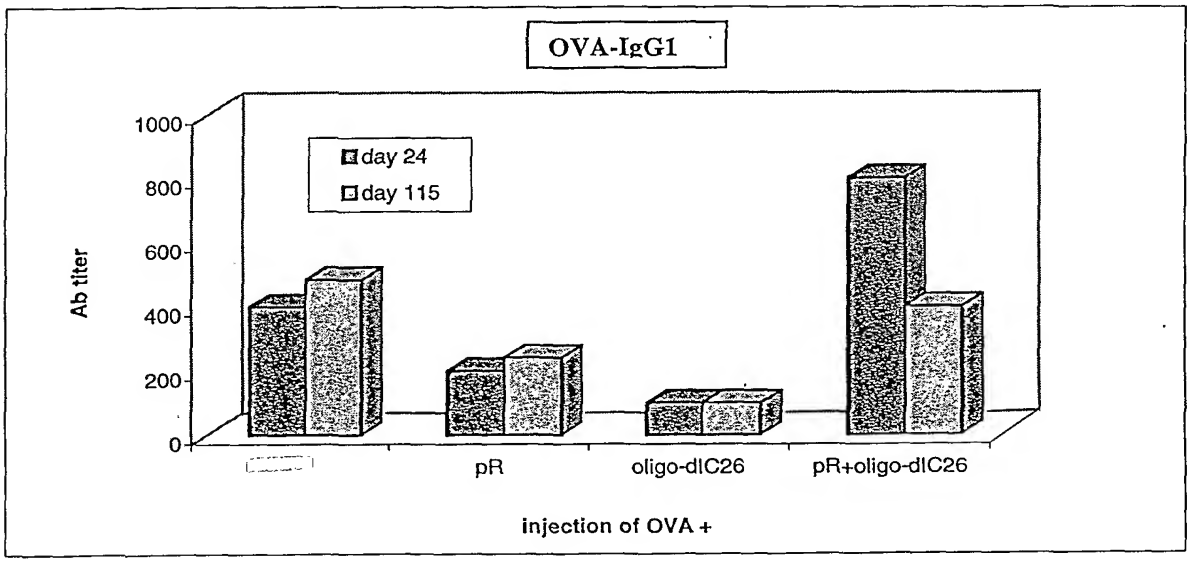

IFN-γ ELISPOT
OVA+o-dIC26+pR
OVA+o-dIC26
OVA+pR
OVA
IFN-γ spots/10⁶ cells
400
300
200
100
0
46
97
days after injection

Figure 13

A)


OVA-IgG2a
200
150
100
50
0
Ab titer
day 24
day 115
pR
oligo-dIC26
pR+oligo-dIC26
injection of OVA +

B)


OVA-IgG1
1000
800
600
400
200
0
Ab titer
day 24
day 115
pR
oligo-dIC26
pR+oligo-dIC26
injection of OVA +

INTERNATIONAL SEARCH REPORT

Ir tional Application No
PCT/EP 01/06437

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61K39/02 A61K39/12 A61K39/39 A61K39/00 A61P37/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, BIOSIS, EMBASE, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 725 545 A (MAES R) 3 April 1973 (1973-04-03) cited in the application the whole document --- -/--	1-14

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 August 2001	23/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Renggli, J

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 01/06437

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	SALAZAR A M ET AL: "LONG-TERM TREATMENT OF MALIGNANT GLIOMAS WITH INTRAMUSCULARLY ADMINISTERED POLYINOSINIC-POLYCYTIDYLIC ACID STABILIZED WITH POLYLYSINE AND CARBOXYMETHYLCELLULOSE: AN OPEN PILOT STUDY" NEUROSURGERY,WILLIAMS & WILKINS, BALTIMORE, MD,US, vol. 38, no. 6, June 1996 (1996-06), pages 1096-1104, XP001000929 ISSN: 0148-396X abstract; page 1101, left-hand column-right-hand column, bridging paragraph	1-14
X	HARRINGTON D G ET AL: "ADJUVANT EFFECTS OF LOW DOSES OF A NUCLEASE RESISTANT DERIVATIVE OF POLY INOSINIC-ACID POLY CYTIDYLIC-ACID ON ANTIBODY RESPONSES OF RHESUS MONKEYS TO INACTIVATED VENEZUELAN EQUINE ENCEPHALOMYELITIS VIRUS VACCINE" INFECTION AND IMMUNITY, vol. 24, no. 1, 1979, pages 160-166, XP001013258 EN ISSN: 0019-9567 abstract	1-14

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/EP 01/06437

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3725545 A	03-04-1973	NONE	